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SHOP INSTRUCTION AT UNIVERSITY OF ILLINOIS

B. W. BENEDICT

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SHOP INSTRUCTION AT UNIVERSITY OF ILLINOIS.

BY B. W. BENEDICT,
Director Shop Laboratories, University of Illinois.

The policy of the University of Illinois in regard to administration of the courses in shop work for engineering students was announced to the Society by Dean W. F. M. Goss in his paper "The Administration of College shop Laboratories" before the Boston convention in 1912. In this paper the author pays a strong tribute to the work done in college shops but warns that changing conditions in industry and engineering demand the consideration of educators if this feature of technical education continues on the same plane of usefulness it has in the past. There is no mistaking his meaning when he says: "From these considerations it should be apparent that the ideals which hitherto have stimulated the work of the shop laboratories are sustained by arguments which are losing force as time proceeds. So true is this that the question is already fairly before the technical schools as to whether the existing shop courses which have served so long and so well shall be entirely abandoned. If not abandoned they must be placed upon a new plane of excellence."

Mindful of the undoubted influence of the shop laboratory upon the development of technical education during the past forty-five years and acknowledging without reservation the value of shop training, in my opinion conventional shop work or manual training no longer has a place in the curriculum of the technical school which seeks to prepare men for conditions confronting its graduates at the present day. The old formulas which served so well in the pioneer days of industry no longer fit in the new order of things and failure on the part of educators to grasp the significance of the upheaval

going on in the industrial world would be disastrous to the shop and correlative subjects. Industry in the past was effective but not efficient. A pioneer product grown to immense bulk on lines of least resistance it knew very little about its complex structure and was too busy to find out. Large markets not especially particular about price demanded organization for tonnage production rather than for economical production. Highly specialized service was not required in a large degree nor was it widely sought.

An inevitable readjustment to changing trade sociological conditions was destined, however, to sweep aside the old structure and supplant it with a new. While the usual processes of evolution had brought about certain changes a new note in industry was sounded in the late eighties, the real effect of which was not apparent for nearly a score of years. Then like a wave "Scientific Management" swept over the country as the topic of the moment. Not only industry but society as well developed an intense interest in this new specific for industrial conditions. Brushing aside all the clap-trap about scientific management which has arisen through misunderstanding of its real significance there stands the unmistakable fact that fundamental changes are taking place in the industrial structure. Principles which ruled heretofore are giving way to those founded upon broader conceptions and higher ideals. Accummulation of knowledge concerning fundamentals is both rapid and wide in scope. The old hazy images around which industry has worshiped are going down before definite standards of attainment, of organization, of methods. Experience moulded on traditional lines is no longer in such demand as that of the trained specialist, leaving the colleges no alternative but reorganization of courses of training if men are to be adequately prepared for the service which industry now demands of them. Such a reorganization presents its difficulties but it must come and quickly if it is to be effective.

The relation between education and industry is indissoluble. The ideals of education are to develop men into better men, morally, mentally and physically; and if an educational system failed in this mission it would pass into decay as a useless feature of society. That it does not decay but continues to exert an ever widening influence in the development of civilization is a sign that education has not failed in the practical achievement of its ideals. The conclusion is also obvious that education has continued to meet the ever changing demands of society. Side by side with the evolution in industry which during the past century has been marked by striking changes from old forms to new, we see equally significant developments in educational methods. From the first, technical education and those special interests of society it aims to serve have enjoyed a particularly close relationship. The first has sought not only to solve technical problems by direct assistance in the research laboratory but also by offering training to young men for the special services required. Industry in return has taken an active interest in education and exerted a powerful influence on its development. The principal demand of industry on education is that it must be "practical" and courses in shop work seemed in large degree to fulfil this requirement. For forty odd years the college shop has flourished in an auspicious environment due to the enthusiastic support manifested by those interests which contributed so generously to the advancement of technical education. It has performed a great and useful service and won its right to a place in the higher institution of technical education but it stands to lose that place if early traditions continue as the source of inspiration for its activities. Originally the one bright "practical" spot in a group of "theoretical" courses, it is now one of the least practical if it offers no more than the traditional form of manual training. Performance of simple shop processes such as have been the rule in these courses without definite relation to elements of time and cost have little value in the training of men who must face

modern industrial conditions. Manipulative processes very properly have a place in secondary school training and some acquaintance with them in that environment is desirable but the college shop must aim beyond this and administer courses relating to the principles underlying the use of these processes in industry. An understanding of the principles of industrial economics, of shop organization, of production, and of executive control, is what industry demands of graduates today, and the shop laboratory largely will fail in its mission if it does not give at least some insight into the nature of these fundamentals.

The need for rehabilitating the ideals which heretofore inspired the work of the shop laboratories at the University of Illinois has led to changes in policy and methods which will be briefly described in the belief that they possess some degree of interest to the society. The reorganization was based on the following conceptions:

(*a*) That the college shop should serve in the function of a laboratory for the demonstration of the principles of industrial organization and management.

(*b*) That the development of manual skill in the use of tools and machinery is of secondary importance to training in the principles underlying the application of human endeavor to industrial operations.

(*c*) That the performance of the so called "fundamental mechanical shop operations" unrelated to the factors of time and cost is not essential in the training of the prospective engineer.

(*d*) That manual training more properly falls within the province of the well organized secondary school than in the higher institution of learning.

(*e*) That the shop laboratories must be "true to life," *i. e.*; correspond in all essentials of methods and equipment to commercial plants of recognized merit.

It is not within the province of this paper to enter into explanations or arguments in defense of the conclusions ad-

vanced above, as it is assumed these are accepted by educators who have correctly sensed the trend of the times. The Illinois plan had its origin in the belief that the function of the shop laboratories of technical colleges is to teach principles rather than practice; leaving the latter training to the secondary schools as their particular task. Further it was considered impossible to teach principles underlying shop processes in an effectual manner without the proper laboratory setting. That is, the machinery, the tools, and the methods, must be efficient and the shop laboratories organized to produce useful work cheaply and in quantity as a regular manufacturing plant. Such a program would introduce conditions into the shop laboratories closely approximating those of the industrial world and bring the student face to face with real problems of production and management. To solve these problems becomes the task of the student who assumes the role of executive and exercises the functions required in operating a manufacturing plant. This training develops those qualities which industry is demanding of college graduates of the present day namely; executive judgment, mental balance, initiative, and aggressiveness.

The success attending the administration of the plan depends, of course, on the same factors that enter into industrial operation but the store of knowledge which is available through the activities of scientific management removes the uncertainty of the issue provided the instructional staff is competent and there are adequate funds for development work. The university fortunately possessed both. In the practical development of the plan the shop laboratories were organized as a commercial plant with a regular line of products to manufacture. To the four existing departments namely: pattern, foundry, forge and machine, a fifth, erecting, was added. An eight-horse-power two-cylinder marine type gas engine of practical design was adopted as the first standard product. An operating plan for the production of this engine by the most efficient methods within the limits of

existing conditions was next worked out and put into effect. New machinery was added, new tools purchased and constructed, jigs and fixtures for rapid and duplicate manufacture designed and made, machinery regrouped, tool and stock rooms reorganized, offices for staff engineers provided in each department, shop operations standardized, instruction cards covering all standard operations arranged, and other details of a progressive shop policy put into effect. The scope of the mechanical organization was the same as in commercial shop practice when similar results are sought, and it may fairly be said that in respect to methods and facilities the shop laboratories are on an equal plane of efficiency with any well organized industrial plant engaged in manufacturing similar products. While great emphasis is placed on mechanical facilities for the rapid production of parts the object is not the attainment of production as a commercial achievement but to provide a medium for demonstrating the principles underlying modern manufacturing methods. It is essential that production be secured not for the sake of profit as in industry but as a laboratory exercise in problems of management. Under standardized shop conditions efficiency of management is expressed directly in the volume and cost of production. With the producing facilities a constant factor obviously the output secured by the various groups of students operating the shops in turn, will determine the degree of efficiency obtained by each group in the exercise of managerial functions. Students registered in shop work are divided into four groups or sections, each one of which is considered as a distinct operating unit. While all sections are engaged in the production of the same product the work of each is conducted separately and the efficiency of operation determined on this basis.

Registration of students in the shop courses averages from 300 to 350 per semester at the present time. The complete course such as taken by the mechanical engineers extends over four semesters or seventy-two weeks of nine hours per

week. The instructional staff consists of eight instructors, two of which are assigned to each of the four main departments. There is also a small force of mechanics and tool room attendants.

The laboratories are established in two one-story brick buildings of similar construction and size. Total floor area 34,000 sq. ft. Approximate value of buildings is $57,000.00. While not of modern construction or ideal arrangement the buildings serve their purpose very well. Shop equipment consists of a rather complete assortment of old and new machinery all of which is in excellent operating condition. Its present salable value is approximately $48,700.00.

With the shop laboratories "commercialized" in respect to methods and equipment, and an operating plan arranged for manufacturing a given product, there remains but to supply the operating forces to complete the essential elements of a manufacturing plant. The latter is accomplished by organizing the student groups into operating forces consisting of executives, clerks and workmen. Assignments to these posts are made arbitrarily but each student is moved periodically from one task to another so that during the course he performs all of the managerial and shop functions. In this way all students get, by direct contact, first hand experience with the various problems of management and production. From operating a machine the student may go to the office as production assistant, then back to the shop as material inspector, or to the stockroom as storekeeper or to the bench, or to the testing department, or to a different machine than the preceeding one. During one week the student may be acting as a shop hand, the next as "boss" of the shop. In the course of three semesters it is expected that every student will have performed all the essential functions of operating the shop plant and possess some understanding of the principles underlying its management.

The time allotted for the shop courses is necessarily inadequate for a complete demonstration of the great problem of

management which in practical life absorbs years of application. Consequently I have no illusions as to what may be accomplished in a few months while the students are in the shop laboratories. Certainly I do not expect that the shop training has the magic power of developing untrained men into full blown executives and managers. On the other hand I am convinced it is possible to develop conceptions of the fundamental principles of management that in later life will prove of immeasurably greater value than that of the traditional shop training.

The shop courses have been developed around the conception that the industrial process is in its elements a simple one of changing materials from one form to another by the application of human forces through the agency of tools. Management as the act of directing the course of these operations involved in this process is concerned with three elements, namely: (*a*) the worker or producing unit, (*b*) the material or the unit worked upon and (*c*) the equipment or the unit worked with. The shop instructional program is divided into three parts for the treatment of the elements just mentioned. This gives a simple and direct method for dealing with a large subject and tends to prevent unprofitable excursions into the realm of non-essentials of which there are legion. The specific features emphasized in the shop courses are listed below in tabular form and immediately following these will be briefly discussed as to aims and methods.

The Worker:

Types of Organization,
Functions of the Executive,
Relations to Industry,
Physical Facts,
Effects of Environment,
Methods of Reward,
Costs of Service.

The Materials:

Studies in Construction and Suitability,
Purchasing Methods,
Storage Methods,
Despatching Methods,
Ordering and Inventory Methods,
Transportation and Delivery Methods,
Costs of Materials.

The Equipment:

Selection and Specifications,
Maintenance Methods,
Operation Methods,
Production Methods,
Standardization Methods,
Testing and Experimental Methods,
Costs of Production.

Types of Organization.—The functional type of operating organization has been selected as the most effective for the shop laboratories and the reasons why are made the basis for a short discussion of the various types of organization and their special application in industry. A graphical representation of this organization is shown in Fig. 1. As shown by the chart the organization is purely functional. The operating staff consists of executives (called engineers for obvious reasons) with functional supervision over the various shop activities as follows:

Design.—Design of products, tools, jigs, facilities, etc., supervision over drawings, tracings, blue prints.

Materials.—Custody of all materials used about the plant; purchasing, storage, and delivery of same.

Production.—All problems of production including routing, despatching and making standard parts; supervision over working forces.

Standard Practice.—Time studies and rate setting of

standard operations; work schedules and instruction cards.

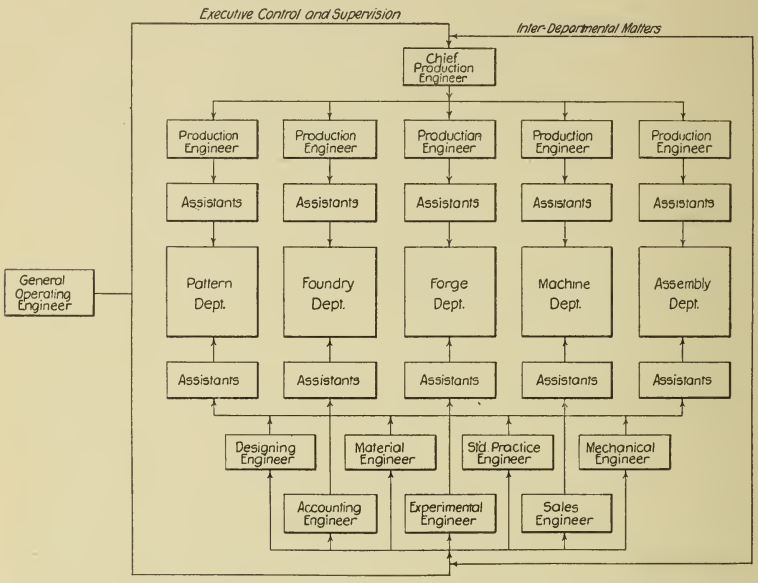


FIG. 1. Chart showing organization of the student operating staffs of the shop laboratories. The organization is purely functional.

Accounting.—Shop cost keeping and accounting incidental to manufacture of product; all shop records and audits.

Experimental and Inspection.—Testing of products; machine production tests; inspection of parts undergoing the process of manufacture.

Sales.—Publicity and advertising regarding product; sales of same; collections.

Maintenance.—Upkeep of plant and equipment; repairs; general shop conditions.

General supervision is vested in the office of general operating engineer which corresponds to that of works manager. The functions of this position are at present assumed by the director of the laboratories. The remaining staff positions

are assigned to students for periods of two weeks. In the second week the students next in line for the positions are "broken in" so the organization is virtually self perpetuating. The duties of each staff position have been carefully outlined so that intelligent and interested students have no difficulty in acquiring the knowledge necessary to perform the functions of the various offices or in grasping the particular lesson which the training aims to give.

The Worker.

Functions of the Executive.—The actual executive work involved in operating the plant is supplemented by lectures designed to illustrate the larger aspects of the executive problem in industry and thereby increase the value of the shop executive training.

Relation of the Worker to Industry.—A glimpse of this great question is given by means of lectures and actual shop experience. Naturally the treatment is limited but it has proved stimulating to that class of students especially interested in the problem of human relations.

Physical Facts about the Worker.—This subject also, from the instructional standpoint can be given but passing attention although it is one of great importance. The human machine and methods for conserving its health and vitality while engaged in industrial occupations are discussed in lectures. The matter of safeguarding the worker is emphasized by an aggressive policy of "safety first" in the laboratories. Instructions in safe practices are given and obedience to them insisted upon in the shop. Cautionary signs and safety notices are placed at various points where such are necessary. Machinery is safeguarded in a substantial manner and every precaution taken to prevent accidents. Students have a safety club with branches in all departments which has for its object the stimulation of greater interest in safety matters.

Effects of Environment on the Worker.—Lectures and

practical demonstrations are employed to illustrate the relation between environment and production. Constant effort is directed toward maintenance of a high standard of shop conditions in respect to cleanliness, light, water, ventilation and sanitation in accordance with good shop practice.

Methods of Rewarding the Worker.—The fundamental principle that the worker is entitled to earnings in proportion to his productive ability is demonstrated in actual practice by a plan of awarding grades according to efficiency in the production of work. All shop operations are standardized and definite time limits set for each. The actual time taken by students to perform shop operations as measured by the standard time allowed determines the efficiency of production. In industry the degree of efficiency attained forms the basis on which earnings are distributed to the worker but in the shop laboratories efficiency is used to determine the grade. Although the nature of the reward is not the same in both cases the principle involved is identical, so that the student is brought into personal contact with the modern system of rewarding labor.

The average efficiency of all students in a section determines the efficiency of that section as a work producing unit. Section efficiency is calculated once each week and posted on the bulletin board. Naturally a great deal of rivalry between sections is stimulated in this way, the effect of which is shown in the machine shop record for one semester as illustrated in Fig. 2. The successes and failures of the section operating staffs in the struggle to lead in efficiency are written graphically on the chart. This friendly contest brings out examples of high grade executive talent and stimulates the majority of students to do their best work.

Costs of Labor Service.—Labor costs of manufacturing the engine and operating the plant are computed by the accounting staffs. Work order cards are issued for all shop operations and student workmen record time "in" and "out" by time clocks upon these cards. The actual time and direct

labor cost are calculated from this card. Indirect and overhead charges are added and the total cost determined. A scale of hourly rates for different classes of service is employed for determining production costs, payrolls, etc. This feature

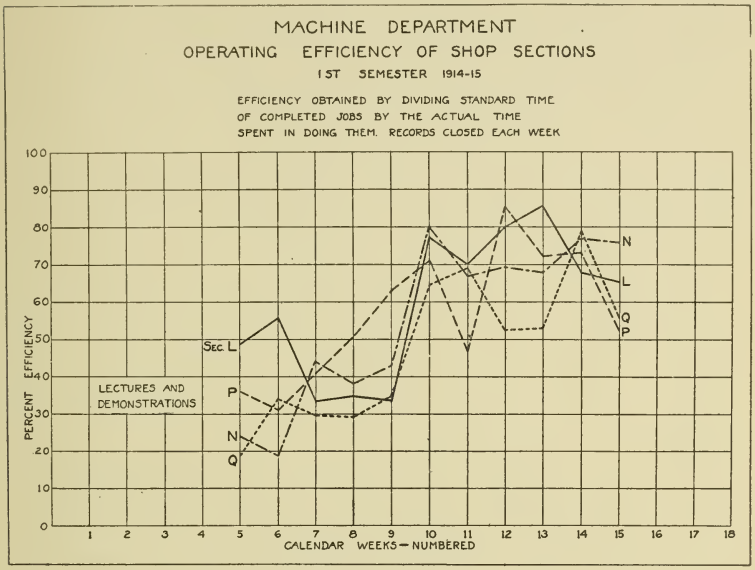


FIG. 2. Chart showing operating efficiency of shop sections in machine shop, for first semester 1914–1915. The upward trend in efficiency during the successive weeks is due to more effective management and greater skill in the operation of machines and tools.

of the course serves to give the student some aquaintance with the principles of cost keeping and more important still an insight into labor costs.

Materials.

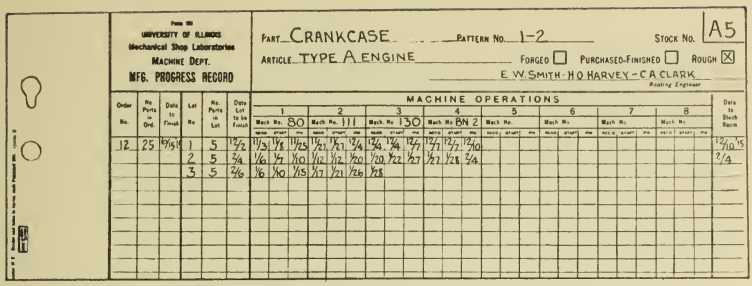
Studies in Construction.—Materials for use in gas engine construction are selected according to standards that prevail in commercial practice. Vanadium steel for connecting rods, aluminum alloy for pistons, nickel steel for valves,

and such metals actually employed in manufacture of the engine are discussed from the standpoint of cost, service, strength and workability. This study of the physical and chemical characteristics of the most widely used metals in industry coordinates with the shop experience of forging, casting, machining and testing of the same metals.

Purchasing Methods.—The materials used in manufacturing the shop products and in the upkeep of the plant are purchased by accepted commercial methods which serve as a medium for demonstrating this feature to the student. Questions of specifications, quotations, markets, trade prices, discounts, etc., are considered and discussed.

Storage Methods.—Materials (both raw and finished) are stored in modern stock rooms. These are in charge of staff material assistants who perform all work in connection with storage of materials and maintenance of stock records. Materials are issued on requisition only. Order and neatness is demanded in all stock rooms.

Despatching Methods.—Standard parts are despatched through the shops on a manufacturing schedule directed by the staff production assistants according to the number of engines to be made. As all manufacturing operations are standardized materials can be moved through the shops with precision and at the desired rate of progress if the shop organization is efficiently directed. To maintain a definite volume of production is the task of the staff production assistants. A record of the movement of parts through the shop is kept as shown on the sample page of the Progress Record in Fig. 3. The standard rate of production is charted and later the actual rate is posted as fast as individual operations are completed for the information of the production assistants. This graphical record is shown in Fig. 3. From this record the work of the production assistants is analyzed and all operating mistakes pointed out and remedies for same suggested. The relation between location of machines and production of parts is treated through lectures and labora-



UNIVERSITY OF ILLINOIS
Mechanical Shop Laboratories
MACHINE DEPT.
MFG. PROGRESS RECORD

PART CRANKCASE PATTERN NO. 1-2 STOCK NO. A5
ARTICLE TYPE A ENGINE FORGED ☐ PURCHASED-FINISHED ☐ ROUGH ☒
E. W. SMITH-H.O. HARVEY-C.A. CLARK
Routing Engineer

Order No.	No. Parts in Order	Date to Finish	Lot No.	No. Parts in Lot	Date Lot to be Finish	MACHINE OPERATIONS 1 Mach. No. 80	2 Mach. No. 111	3 Mach. No. 130	4 Mach. No. BN 2	5 Mach. No.	6 Mach. No.	7 Mach. No.	8 Mach. No.	Date to Stock Room
12	25	6/6/14	1	5	12/2	11/25 1/8 1/25	1/6 1/21 1/24	1/24 1/24 1/29	12/6 12/7 12/10					12/10/15
			2	5	3/4	1/6 1/7 1/10	1/12 1/12 1/20	1/20 1/22 1/27	1/27 1/28 2/4					2/4
			3	5	2/6	1/6 1/10 1/15	1/17 1/21 1/26	1/28						

PAGE FROM MANUFACTURING PROGRESS RECORD

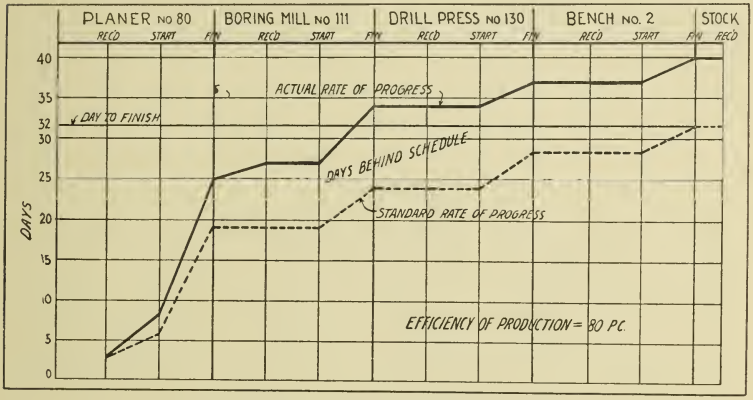
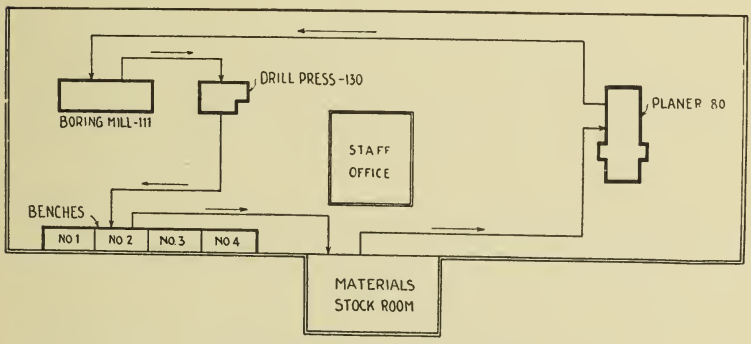


CHART SHOWING ACTUAL AND STANDARD RATE OF PROGRESS



ROUTING DIAGRAM SHOWING PATH OF TRAVEL

FIG. 3. The principles underlying the routing and despatching of parts in the manufacturing process are illustrated in practice, and graphical methods are employed in the study of these principles.

tory practice. Routing diagrams (Fig. 3) showing path of travel from one machine to another during the process of manufacture are developed in the study of the despatching problem. The staff offices are equipped with production despatch boards from which the staff assistants control the movement of parts. Training in the principles underlying despatching is real and therefore effective.

Ordering and Inventory Methods.—After the year's output of engines is decided upon orders for the necessary materials are placed by the staff material assistants on the various departments. Delivery dates and quantities are specified. All materials are ordered on requisition. Stores records showing stocks on hand, deliveries, orders, etc., are maintained by staff material assistants. Inventory of all stocks of raw and finished materials is made once a year to check the daily balances of the material records. The problem of material supply in manufacturing is brought forcibly to the students' attention by this feature of the course.

Transportation and Delivery Methods.—The usual shop facilities of overhead cranes, elevating trucks and common trucks are employed to move materials and studies are made to determine the expense of the various transportation methods.

Item.	Operation Routine.	Standard Time.
1.	Clamp chucking attachment to face plate	0.12
2.	Place casting in chuck and adjust to run true	0.08
3.	Place special boring bar in position on cross slide and 3 63/64″ boring tool in bar and bore out. Speed No. 5. Feed No. 3.	0.50
4.	Change boring bar end for end; place 1/2 × 1/2 tool in bar and face off and flare end as per sketch.	0.30
5.	Slack off chuck set screw, place 4″ reamer in tailstock and ream. Speed No. 10. Feed by hand.	0.12
6.	Remove casting from chuck and place in tote box.	0.04
7.	Remove all tools and fixtures from machine.	0.12
	Standard time in lots = Total pieces × 1.04 plus 0.24	
	Total standard time	1.28

This is lower portion of Fig. 4, Page 251

Costs of Materials.—Material costs are calculated by the staff accounting assistants from the shop records and the value of the material in each gas engine part determined. This and the labor cost keeping is carried on simultaneously by the same staff by methods employed in commercial practice. The object of this feature of the course is to give the student a conception of material costs; the accounting work is incidental.

Equipment.

Selection and Specifications.—Equipment for economical production of gas engine parts is considered in lectures which coordinate with studies of the shop laboratory equipment in which its fitness or otherwise for manufacturing the engine is investigated. Trade papers and catalogs are used to supplement other data in developing an ideal layout of facilities for producing gas engine parts in the shop laboratories. While this problem is admittedly narrow in scope it is of topical interest and serves to illustrate the broad principles underlying the selection of manufacturing facilities for economical production of parts.

Maintenance Methods.—Repairs and upkeep of shop facilities and general maintenance of the plant are under the supervision of the staff mechanical assistants. Responsibility for the operating condition of tools, machines, belting and in fact all the material property of the plant is placed squarely before this staff. High standards of maintenance are demanded as in efficient commercial plants which imprints an important lesson on the students which is certain to be useful in later life.

Operation Methods.—It is intended that training in machine operation embody the latest and most efficient practice. Preparation included, selection of proper tools and machines, development of special tools, jigs and fixtures, determination of economical methods of production and standards of time for performing shop operations. Standard operating pratices for all shop processes of manufacturing the gas en-

gine are arranged in the form of instruction cards as illustrated in Fig. 4. Reference to this card which is typical

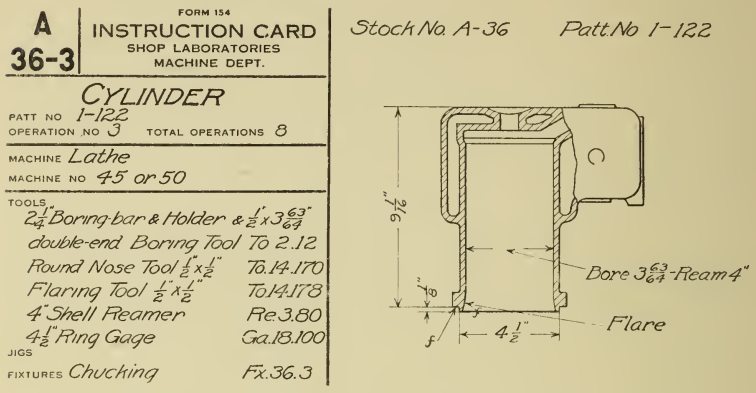


FIG. 4. A typical instruction card. Every operation in manufacturing the gas engine has been standardized and the practice arranged in the form of instruction cards. The number of operations standardized is over five hundred.

shows that the machine, tools, jigs, etc., are specified and also the successive steps in the operation with standard time allowances for performing the work. Operations are to be performed in exact accordance with the instruction card.

The marked increase in output which results from the use of standardized methods is illustrated by demonstrations in which shop jobs are performed in the old style "hit or miss" way and then repeated by the carefully prepared methods of the instruction card. The time lost in the first operation from waste motions and inefficiencies is readily recognized by students making studies of both. Stop watches are used to time the successive motions which are recorded on special forms for the purpose. Following the demonstration the data collected is carefully analyzed and conclusions drawn. Lectures on the principles of standardization applied to shop operations supplement the demonstrations and actual shop work. Skill in manipulation is not sought primarily but out-

put is encouraged in order to show the student the possibilities of large production by effective use of small intervals of time.

Production Method.—At the beginning of the year the Director issues an order on the shop laboratories for the manufacture of a certain number of gas engines. The size of the order is governed by the number of students registered in the shop courses and it represents the maximum output under existing circumstances. Delivery of the required number of finished engines in good order and up to the tests and specifications becomes the shop problem for the year. This calls for the united efforts of all the operating staffs and effective cooperation with the production assistants upon whom falls the responsibility of the final processes of machining, assembling and finishing the product. The production staff occupies an exceedingly important position in industrial organization as it controls the volume of production. Any inefficiency here is disastrous regardless of the manner in which the other operating staffs perform their work, consequently it is essential that the production staff is organized for efficient performance of its functions.

Production is directed by production assistants from despatch boards located in the staff offices. The boards are designed to show the production situation of the entire shop practically at a glance. As the status of each operation in respect to the predetermined production schedule is always before the staff the work can be directed intelligently through the shop channels. The boards are changed immediately upon receipt of information from the shop so they are always up to the moment. The ease of control over shop production and the effectiveness of the methods employed is forcibly impressed upon the students, and their interest and resourcefulness in this phase of the work has been very gratifying to the instructional staff.

The actual work of production is stimulated by the use of modern shop facilities, standardized tools, methods and proc-

esses. Jigs and fixtures are used largely in the manufacture of parts. A typical group of these is shown in Fig. 5. The

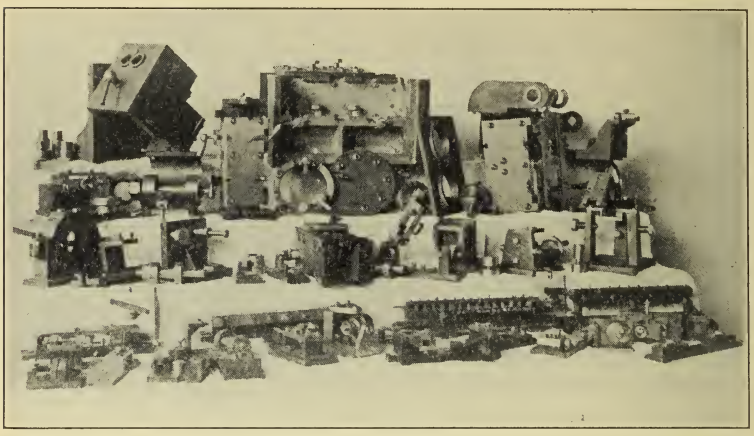


FIG. 5. A typical group of jigs and fixtures used in machining gas engine parts in the machine shop. There are over one hundred of these in this department alone. They are built by regular tool makers from practical designs. It is aimed to have special tools for every shop operation where such will reduce the time and cost of the work.

effect of modern production methods on output is illustrated by means of demonstrations in which operations are performed with and without special tools and jigs. All shop work is confined strictly to gas engine production and special jobs required about the plant. Students are assigned work by the production assistants according to the production schedule without regard to its nature. Parts are manufactured in lots, the size of the part determining the number in the lot. With some of the smaller parts fifty pieces will constitute a lot. The various lots go through the shop intact, the different operations being performed by students in turn. That the work is useful and conducted in a practical way makes a strong appeal to students taking the course.

Standardization Methods.—In preceding paragraphs atten-

tion has been called to the use of standard tools, parts, methods and practices in the shop laboratories. In respect to standardization of these items the same shop policy has been followed as in the best commercial practice. It is the aim to maintain standard shop conditions for the purpose of demonstrating the principle of standardization to manufacturing processes. Standards based on any but accurate and conclusive data have no value—in fact inaccurate standards introduce some very dangerous elements into shop operation. Methods of analyzing shop processes into the elementary details and then of correctly interperting the accumulated information are taught by precept and laboratory practice. In the shop, time studies are made by a staff of standard practice assistants of shop operations on the gas engine using stop watches for timing the successive motions employed in performing the work. Times are recorded in hundredths and thousandths of hours. These studies are repeated by different students until a certain number have been made. They are then carefully compared item by item and a tentative work schedule prepared. If subsequent examination confirms the accuracy of the data it is arranged in the form of instruction cards.

Testing and Inspection Methods.—Inspection of parts undergoing the process of manufacture is conducted by a staff of inspection assistants. As efficient inspection is an important detail of shop operation it is given considerable attention in the shop courses. Inspection is made of every part at the completion of each operation. Thus if six operations are required to complete a part it is given six inspections which leads to rejection of the part for defects in material or dimensions before subsequent work is done upon it. Each department has an inspection office equipped with the necessary inspection facilities. Views of a typical office and facilities are shown in Fig. 6. Inspections are rigid and parts not finshed within the limits allowed by the inspection standards are rejected summarily. Facilities for inspection are com-

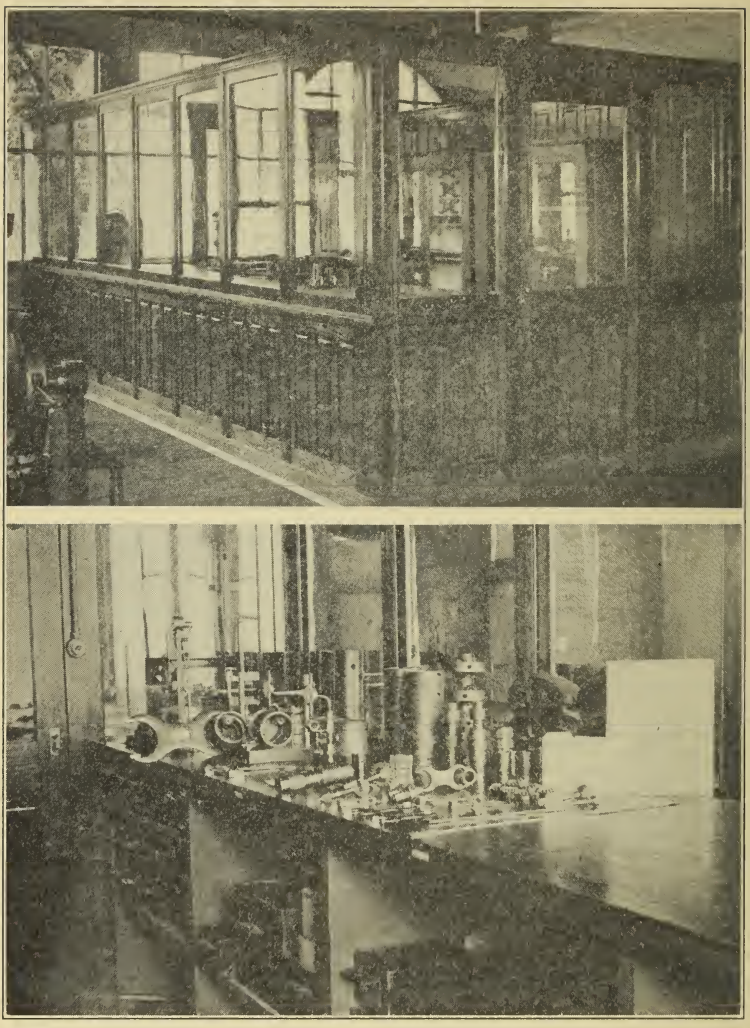


FIG. 6. Exterior and interior views of inspection office in machine department. The construction is typical of all staff offices. Testing appliances correspond in type and number to industrial practice. The tote boxes containing the work are below the bench in the lower picture.

plete and the instructions specific so that if poor inspection occurs it is traceable to the student responsible. In the course of the training of inspection students use practically all of the important types of plug, ring, snap, dial and surface gauges, micrometers, sclerescope, gear tester and testing machine in the operation of checking dimensions, hardness, strength and accuracy of parts made of the most common metals used in manufacturing.

The same staff conduct tests of the gas engine and also tests of machines in drilling and turning metals. After assembling, gas engines are delivered to the testing department for test. Here the engines are "broken in" on a special testing rack for several days and a careful record made of all defects, should such appear. Test for horse-power rating is then made and the engines returned to the assembly department for painting and finishing.

A high production drill press and a heavy engine lathe have been equipped with dynamometers for the purpose of demonstrating the performance of drills and lathe tools in the production of work, the power consumption, and other important data. This development in the shop courses has not as yet taken definite form but it is mentioned here as a matter of interest. There are large opportunities in experiments of this kind for rounding out the experience of students with machines and materials which would be impossible by any other method.

Costs of Production.—The functions of the staff of accounting assistants in shop cost keeping has been explained previously in connection with the items of labor and material. The costs of labor and materials plus overhead and fixed charges constitute the total expense of production. This figure is determined for the gas engine to give the students some experience in cost keeping but principally to pass the great question of cost in review before them—as cost is the rock upon which industry breaks, if it breaks at all.

The shop courses at Illinois are more than a matter of jigs

and instruction cards. These and other elements of modern industrial processes mean little in themselves. Their application is the important thing. In the shop courses the possession of modern equipment and methods does not insure effective training in shop practice, but the latter is impossible of achievement without the aid of suitable methods and equipment. In Illinois the method of attack was directed first at the shop, its equipment and methods with the object of developing a real laboratory for demonstrating the principles of efficiency through the practice of these principles.

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